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THESIS

A MARINE CORPS ENLISTED INVENTORY PROJECTION MODEL USING YEARS OF SERVICE AND PAY GRADE

by

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December 1998

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13. ABSTRACT *(maximum 200 words)*

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This thesis created an enlisted inventory projection model that forecasts required accessions using years of service (YOS) and pay grade as variables, whereas the current projection model in use at HQMC has only the YOS dimension. It is expected that by adding the pay grade variable, the model can more accurately calculate attrition, demotion, and promotion rates within each combination of pay grade-YOS category. This Excel based model has been constructed using forecasting techniques where attrition, promotion, and demotion rates are based on either a straight average, one specific fiscal year, a two year weighted average, or a three year weighted average. This model is an easy-to-use tool with flexibility to perform quick calculations of several scenarios for analysis, ultimately providing efficiency and accuracy in manpower planning. The model also has the potential to enable manpower planners to do more detailed end strength analyses

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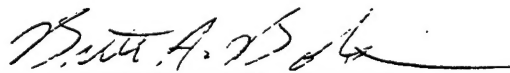B.S., Auburn University, 1991

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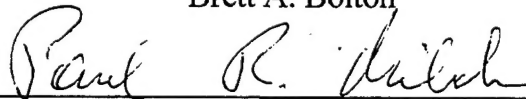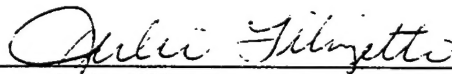from the

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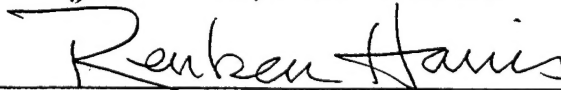
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I. INTRODUCTION

With 174,000 Marines on active duty, the Marine Corps has a vested interest in personnel planning. Maintaining the correct enlisted force structure within the Marine Corps is of extreme importance, as the Marine Corps believes that the individual Marine is its most effective weapons system. [Ref. 1: p. 16] In order to maintain its end strength, the Marine Corps must ensure it recruits and retains the right number of people with the right set of skills. This requires planners to be able to accurately predict the behaviors of the Marines in an ever changing socioeconomic environment. Without proper planning of the enlisted force structure many problems could arise including rank stagnation, poor morale, loss of highly skilled and desirable Marines, undermanned units, etc. All of these would ultimately affect the ability of the Marine Corps to successfully accomplish its mission.

In order to plan effectively, the Marine Corps relies on the use of modeling to maintain force structure. The Marine Corps has always used various models to assist them in manpower planning. In recent years, the capabilities of personal computers and software have improved to the point where it is now possible to create and operate even sophisticated models on them. A personal computer model to forecast the number of accessions needed to maintain the enlisted force of the United States Marine Corps (USMC) is one such model that would be useful for the USMC. The enlisted end strength planner for the Marine Corps has requested that a thesis explore the possibility of creating such a model to assist his office in accomplishing this task.

A.   BACKGROUND

The need to accurately forecast accessions within the Marine Corps is derived from the mission of the enlisted end strength planner. This officer is expected to accurately forecast the number of accessions needed to maintain the Marine Corps' enlisted active-duty force at approximately 155,000 Marines. [Ref. 2] The enlisted end strength planner must also consider that at the end of each Fiscal Year (FY), the officer and enlisted personnel strength cannot be more than one-half percent below and one percent above 174,000. [Ref. 2] Such mandates are imposed by Congress on all branches of the armed forces. Even more importantly for the Marine Corps, the ability to maintain end strength through the correct number of accessions directly affects the Marine Corps' ability to accomplish its missions. Subsequently and more directly, the impact of the accuracy with which accessions are determined is extremely important to recruiters, whose mission is a very challenging one, even in the best of times.

The current model being used by the enlisted end strength planner was created a few years ago relying heavily on the experience of manpower analysts at Headquarters, USMC. [Ref. 3] This model is based on the continuation rates of Marines within each year of service (YOS), without taking into consideration the pay grade of the Marines. By adding the pay grade variable, the model to be constructed in this thesis should make it possible to calculate attrition, demotion, and promotion rates, in lieu of continuation rates and do so by pay grade as well as by YOS. For example, the pay grade variable allows the model to determine the attrition rate of E-1's with 6 YOS and E-5's with 6 YOS separately, unlike the current model which uses an average continuation rate for all personnel with 6 YOS across

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all pay grades. The fact is that the continuation/attrition behavior of an E-1 with 6 YOS is going to be drastically different than that of an E-5 with 6 YOS. This model will also use promotion and demotion rates which are absent in the current model. This should contribute to a more accurate estimate of required accessions, which is the primary goal of the model.

B.   OBJECTIVES

The objective of this thesis is to develop an enlisted inventory projection model by years of service and pay grade for the Marine Corps enlisted end strength planner. This model should be able to predict future end strength more accurately, thus providing the planner with better information for policy analysis pertaining to end strength issues. The model will use Microsoft Excel, allowing planners to determine the effects of policy changes on end strength through the use of a desktop computer. Additionally, the planner will be able to accurately answer questions such as: How many recruits will be needed next year in order to maintain the current end-strength? How many recruits will be needed if the Marine Corps were to downsize by 5000 next year? Is there a problem with attrition amongst E-5's with 5-8 YOS? Have demotion rates increased for E-4's with 1-4 YOS during FY 1997?

C.   RESEARCH QUESTIONS AND METHODOLOGY

Can an accurate inventory projection model for Marine Corps Enlisted Personnel be designed using years of service and pay grade as variables to determine the annual accession requirement for maintaining the specified end strength?

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Can this model be designed with a user-friendly interface and remain adaptable to allow for ease of use, maintainability, and flexibility using a desktop computer spreadsheet?

This thesis provides a model that answers the above research questions. The model can be used to predict the accurate inventory of Marine Corps enlisted personnel using years of service and pay grade as variables, if accurate data are obtained from the Marine Corps Historical and Statistical Files. The model also predicts the annual accession requirement for maintaining or achieving specified end strength. The model is Excel based and makes use of another dimension of data, namely pay grade, which is not used in the current model. This model is designed with a user-friendly interface allowing for maintainability, flexibility and is simple to understand with a minimum of training.

The Enlisted Plans Section of Headquarters Marine Corps (HQMC) has been the primary source of information about end-strength planning, and has provided the author with the current inventory projection spreadsheet model and additional data from which the research for this thesis was conducted. The data contained information from the Marine Corps Historical Files and the Statistical Files for FY94 - FY97. The Historical Files provided the data for the beginning strength of each fiscal year, or the number of Marines by YOS and pay grade who were enlisted on 1 October of the respective fiscal year. The Statistical Files contain data on each personnel action for each individual Marine during a given fiscal year. Namely, information is provided whenever a Marine is promoted, demoted, or attrited during the fiscal year. Using Statistical Analysis Software (SAS), these data were manipulated in order to obtain counts of promotions, demotions and attritions by YOS and pay grade during each FY. With these data, a Markovian model [Ref. 4] was

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constructed for the purpose of forecasting future end strength from which the number of accessions needed to maintain the Marine Corps at the mandated manning levels can be deduced.

According to Bartholomew et al. [Ref. 4: p. 1], manpower planning calls for statistical expertise in uncertainty. "This arises both from the uncertainty inherent in the social and economic environment in which the organization operates and from the unpredictability of human behavior." This uncertainty necessitates the construction of forecasting models in manpower planning; in this case, models forecasting future end strength of enlisted Marines. Markovian models have been around for some time, but the above reference provides the best currently available general guide to them in manpower planning. [Ref 3] The model constructed in this thesis is basically a Markovian model as well, in the sense that future end strengths are forecasted from current inventories in the various categories, although historical rates (attrition, promotion, and demotion) are also made use of in the process. This way the model produces forecasts by extrapolating the historical behavior of Marines into the future. Historical rates can be used in several ways, as is explained by Eppen et al. [Ref. 5: chp. 13] This model makes use of four forecasting techniques: Straight Average, Naïve, Two Year Weighted Average, and Three Year Weighted Average, which are discussed in general terms by Eppen.

D.   SCOPE AND LIMITATIONS

This thesis will focus on the creation of an inventory projection model to be used by the Marine Corps enlisted end strength planner. Four fiscal years (FY94 - FY97) of

historical data will be used to forecast future trends. Four forecasting techniques will be suggested: straight average, naïve, two year weighted average, and three year weighted average as mentioned above in Section C. However, the model will be constructed so that more than three FYs can be easily coded into the straight and weighted average techniques.

E.   ORGANIZATION OF THESIS

A short explanation of the current model used at HQMC is explained in Chapter II, where the new model's construction is also described. This includes a discussion of the main model components, explanation of how the model works, and an assessment of the model. Chapter III is a comprehensive explanation of the results obtained within this thesis. The conclusions and recommendations are presented in Chapter IV. The Current Model's Continuation Rates, "Raw Numbers" Matrices, User's Manual, and the SAS coding are provided as Appendices A, B, C, and D respectively.

II. ENLISTED INVENTORY PROJECTION MODEL

In this chapter, the inventory projection model currently in use at HQMC will be discussed from both a mathematical and a user perspective. After expounding upon the advantages and disadvantages of this model, the new inventory projection model will be introduced. This model's many assets will be explained, and a description of how they overcome many of the disadvantages that exist with the current model will be provided.

A. DESCRIPTION OF CURRENT ENLISTED INVENTORY PROJECTION MODEL

The current model was developed by the Enlisted Plans Section as an easy-to-use reference tool to analyze policy decisions quickly with their personal computers. It has been an effective tool for the section and this part of the thesis will answer the following questions. How does it work? What kind of forecasting techniques does it use? What are the advantages and disadvantages of this model?

1. How Does it Work?

The data required by this model is quite minimal. This model relies solely on fiscal year beginning strengths by pay grade and YOS as shown in Table 2.1. Currently the model uses the beginning strengths for FY86 - FY98. From these beginning strengths, continuation rates are calculated in accordance with the following formula:

$$\text{Continuation Rate for all paygrades with a YOS in FY} = \frac{\text{Total of all paygrades with (YOS + 1) in FY + 1}}{\text{Total of all paygrades with YOS in FY}}$$

Begin Strength: FY 86

YOS	0	1	2	3	...	28	29	30	total
e-1	11903	797	352	231	...	0	0	0	13483
e-2	14845	5670	1143	725	...	0	0	0	22637
e-3	3548	23764	18468	7490	...	0	0	0	54934
e-4	220	2610	6808	11028	...	0	0	0	32285
e-5	45	87	543	1523	...	0	0	0	24765
e-6	8	20	17	21	...	0	0	0	15533
e-7	3	3	0	1	...	0	0	0	9242
e-8	0	1	0	1	...	2	3	1	3708
e-9	0	0	0	1	...	126	98	21	1310
total	30572	32952	27331	21021	...	128	101	22	177897

Table 2.1 Example of Beginning Strength Matrix

For example, the continuation rate for YOS 0 in FY86 is 0.9029, which means that 90.29% of the Marines with 0 YOS in FY86 remained in the Marine Corps. This is calculated by dividing the total of all pay grades with YOS 1 in FY87 (or 27,604) by the total of all pay grades with YOS 0 in FY86 (or 30,572). When this is done for all YOS's, the result is the matrix of continuation rates for FY's 1986 through 1997 presented in Appendix A. These continuation rates may then be aggregated by a number of techniques. The name "naïve" is given to the simplest of these techniques. It is calculated by simply using the continuation rates for one FY (e.g., FY96) as the factors to be used in forecasting next year's stocks. Naïve I and II named in this model use this technique currently with FY96 and FY97 continuation rates. "Straight average" continuation rates are determined by summing all continuation rates from several FY's divided by the number of FY's used in the summation. The "adjusted average" continuation rates are calculated exactly the same way, except for

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discarding certain FY's due to some specific reasons. For example, if the designers believed the continuation rates were over-inflated, under-inflated, or generally not reasonable in some FY then that FY's data would be disregarded. The "weighted average" technique is used by placing various weights on the continuation rates of each FY and then summing them. The most recent FY is usually weighted the most heavily, the next FY receives the second largest weight, etc, while the oldest FY has the smallest weight.

The forecast of end year strength is then accomplished by multiplying the beginning strength of the current FY by the continuation rate, as computed by one of the techniques described above, for each YOS, and summing over all YOS. The resulting end-strengths are given in Table 2.2 for the various forecasting techniques. These numbers represent the total number of Marines forecasted to remain in the Marine Corps at the end of the FY. This is

	Naïve I	Naive II	Straight	Adjusted	Weight I *	Weight II **
FY98 Total Forecast	126850	126114	127067	125965	126552	126409

* (.5*FY 97) + (.3*FY 96) + (.2*FY 95)

** (.6*FY97) + (.4*FY 96)

Table 2.2   Forecast Totals for FY98

then subtracted from the total number of enlisted Marines authorized to determine what is called the "total non-recruit attrition". For example, the FY98 straight average forecast is 127,067. This represents the number of Marines forecasted by straight average technique that will remain in the Marine Corps to the end of FY98. This number is then subtracted from the total number of enlisted Marines authorized for FY98, namely 154,922. The difference of 27,855 represents the total number of non-recruit attrites forecasted by the

straight average technique. Then the number of expected recruit attrites (or 4644) is added

to this figure to obtain the forecasted accession requirement of 32,499 for FY98. Recruit

attrition is a number obtained through the Marine Corps Statistical Files and is entered by

the user. It is the number of recruits who attrite before completing basic training. See Table

2.3 for the forecasted accession requirements using the other techniques, as well.

	non-recruit attrition	recruit attrition	accession requirement
straight average:	27855	4644	32499
adjusted average:	28957	4644	33601
naive:	28072	4644	32716
naive II:	28808	4644	33452
weight I:	28370	4644	33014
weight II:	28513	4644	33157

Table 2.3 Example of Accession Requirement

2. Advantages

The biggest advantage of this model is its inherent conceptual simplicity. It is easy

to understand and use, requiring the user to provide relatively little input. Maintaining this

model over the years also requires minimal effort, since the only new data needed to update

this model is the beginning strengths of each new FY, which can easily be obtained using

the Marine Corps Historical and Statistical files.

3. Disadvantages

First of all, the organization of the current model is such that it can be difficult for

the inexperienced user to follow. This is mainly due to a lack of titles/labels, definitions, or

explanations within the model. It can also be difficult to maneuver through the model, because it is constructed on one sheet making it too large and cumbersome to handle.

Generally an analyst wants to research a number of different scenarios before presenting any analysis. However, this model does not allow the user to easily manipulate the forecasting techniques, therefore, it does not provide the user with the option of comparing many different scenarios. This limitation makes the model inefficient for the user.

The model also contains a mathematical flaw. It straightforwardly averages rates, which may lead to a large bias in some cases. Unless all of the numbers in various FY's are approximately of similar magnitude, averaging rates this way may produce heavily biased values. The proper way of "averaging" rates will be explained in the description of the new model in Section B.

Another assumption of this model is that all personnel within a certain YOS, regardless of pay grade, will behave the same way. This assumption is inherent in computing continuation rates by YOS only, aggregating over all pay grades. This may lead to continuation rates that are highly inaccurate, because the fact is that an E-5 with 6 YOS is likely to act differently than a E-1 with the same 6 YOS. The E-1 with 6 YOS is most likely a Marine who has been disciplined and demoted to E-1. This Marine is unlikely to be promoted and is probably on the way out of the Marine Corps. The E-5 with 6 YOS, however, is on a regular track of progression through the ranks. This Marine stands a much better chance of not attriting and being promoted. Therefore, lumping together all pay grades for each YOS in the computation of continuation rates could cause the forecast to be

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highly inaccurate. The next section will explain how the new model proposes to overcome these disadvantages.

B. DESCRIPTION OF THE ENLISTED INVENTORY PROJECTION MODEL USING YOS AND PAY GRADE AS VARIABLES

The new enlisted inventory projection model using YOS and pay grade as variables is a more elaborate model than the current model. How this model is constructed, its advantages and disadvantages will be discussed in this section.

1. Construction of the Model

a. Data

The basic concept of this model is simple. In order to forecast next year's stocks, the numbers in all cells are advanced by one YOS, then losses are subtracted and gains are added cell by cell (or category by category) as they occur during the FY. Here, a cell or category is defined as any combination of pay grade and YOS, e.g., E-1, YOS 0 is one cell or category, while E-5, YOS 8 is another.

The model is Excel based and is contained in a single workbook with eight worksheets. The basic information used by the model is on the worksheet named Raw Numbers. This sheet provides the following matrices for each FY upon which this model is based:

Beginning Strength
Attrites
Demotees From
One Grade Demotees To

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Two Grade Demotees To

Promotees From

One Grade Promotees To

Two Grade Promotees To

Recruits

Throughout this thesis, whenever these matrices are mentioned, they will be presented in bold to minimize any grammatical confusion these names can cause.

Each matrix is a rectangular array of numbers, where rows represent YOS and columns stand for pay grades. These matrices supply the data from which the forecasting of this year's end strength (which is identical to next FY's beginning strength) can be accomplished. This portion of the data is generated from the Marine Corps Historical and Statistical Files and must be obtained in a specific way.

All of the matrices except recruits are created as "transitional data". [Ref. 6: p. 37). This means that the Marines counted within each category must have been in that category at the beginning of the FY. Recruits, on the other hand, must be classified into categories according to where they are at the end of the FY during which they entered the Marine Corps. This means that Marines who attrite within the same FY of their accession will not be represented in the model.

Using such categorization, the number of Marines at the beginning of a FY may be represented by the matrix of **Beginning Strength** such as shown in Table 2.4 for FY 1994.

YOS/Pay Grade	Beginning Strength FY 94			
	e-1	e-2	e-3	e-4
0	10189	15568	3711	3
1	337	3432	20825	651
2	202	703	14391	5043

Table 2.4 Beginning Strength Matrix

Note that although the full matrix contains 31 rows and 9 columns (representing all YOS's and pay grades), it is shown here in an abbreviated format, while the full matrix is shown in Appendix B. This format is followed here with all other matrices, as well.

Another matrix called the **Attrites** matrix represents the number of Marines from each category who (for a variety of reasons) have left the Marine Corps during a FY. See Table 2.5 for the FY94 **Attrites** matrix.

YOS/Pay Grade	Attrites FY 94		
	e-1	e-2	e-3
0	987	1986	533
1	84	276	833
2	54	140	775

Table 2.5 Attrites Matrix

Note that these Marines were categorized at the beginning of the FY in which they attrited. For example, the 987 Marines shown in category E-1, YOS 0 began the year in that category and then attrited during FY94.

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Demotees From is a matrix of Marines who were demoted out of a pay grade during the FY. See Table 2.6 for the FY94 **Demotees From** matrix. For example, the category E-3, YOS 0 has 99 Marines who started the FY in that category and then were demoted to E-2 or E-1 during the same FY.

YOS/Pay Grade	Demotees From FY 94		
	e-1	e-2	e-3
0	0	191	99
1	0	69	594
2	0	19	350

Table 2.6 Demotees From Matrix

The **One Grade Demotees To** matrix is the number of Marines demoted one pay grade during the FY to the category. See Table 2.7 for the FY94 **One Grade Demotees To** matrix. For example, the 191 Marines in category E-1, YOS 0 were all demoted into that category from the category E-2, YOS 0 during FY94.

YOS/Pay Grade	1 Grade Demotees To FY 94		
	e-1	e-2	e-3
0	191	73	0
1	69	432	8
2	19	249	92

Table 2.7 One Grade Demotees to Matrix

The **Two Grade Demotees To** matrix represents the number of Marines demoted two pay grades during the FY to the category. See Tables 3.8 for the FY94 **Two Grade Demotees To** matrix. For example, the 26 Marines in category E-1, YOS 0 of the

Two Grade Demotees To matrix were all demoted into the category from E-3, YOS 0 where they were at the beginning of FY94.

YOS/Pay Grade	2 Grade Demotees To FY94		
	e-1	e-2	e-3
0	26	0	0
1	162	0	0
2	101	7	0

Table 2.8 Two Grade Demotees to Matrix

The **Promotees From** matrix is a depiction of the enlisted Marines who were promoted from a category during the FY. See Table 2.9 for the FY94 **Promotees From** matrix. For example, the category E-1, YOS 0 shows the 8503 Marines who were promoted from that category during FY94.

YOS/Pay Grade	Promotees From FY 94		
	e-1	e-2	e-3
0	8503	13366	687
1	125	2658	6123
2	35	317	7754

Table 2.9 Promotees From Matrix

The **One Grade Promotees To** matrix represents the Marines who were promoted one pay grade during the FY to the category. See Table 2.10 for the FY94 **One Grade Promotees To** matrix. For example, the 50 Marines present within category E-2, YOS 1 were all promoted into this category from E-1, YOS 1.

	1 Grade Promotees To FY 94		
YOS/Pay Grade	e-1	e-2	e-3
0	0	2889	13031
1	0	50	2486
2	0	19	309

Table 2.10 One Grade Promotees To Matrix

The **Two Grade Promotees To** matrix is the same except it depicts
Marines who were promoted two pay grades during the FY to the category. See Table 2.11
for the FY94 **Two Grade Promotees To** matrix. For example, the 16 Marines depicted in
category E-3, YOS 2 were all promoted into this category from the category E-1, YOS 2,
during FY94.

	2 Grade Promotees To FY 94		
YOS/Pay Grade	e-1	e-2	e-3
0	0	0	5614
1	0	0	75
2	0	0	16

Table 2.11 Two Grade Promotees To Matrix

The **Recruits** matrix is the number of Marines who joined the Marine
Corps during the FY and are classified at the pay grade and YOS they obtained by the end
of the FY. See Table 2.12 for the FY94 **Recruits** matrix.

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YOS/Pay Grade	Recruits FY 94				
	e-1	e-2	e-3	totals	
0	11437	13529	2453	27455	
1	26	427	350	808	
2	0	3	3	7	
Totals	11464	13961	2814	28356	Totals

Table 2.12 Recruits Matrix

For example, the 26 Marines presented within category E-1, YOS 1 were recruited during

FY94 and ended the FY with a pay grade of E-1 and YOS 1. Note that recruits who attrite

during the same FY in which they join the Marine Corps are not represented in any

category.

All of these matrices discussed provide the basic data from which the

model is built. Without reasonably accurate data for these matrices from the Marine Corps

Historical and Statistical Files, the accuracy of the forecast will be downgraded.

b. Forecasting Methods

(1) Using Naïve Rates. The easiest way to describe the concept of

forecasting in this model is to illustrate the simple naïve approach. The naïve approach is

nothing more than using a single FY's rates to forecast next year's beginning strengths from

this year's beginning strengths. This method is generally applied when conditions during

the coming FY are expected to be very similar to those of a previous FY, possibly resulting

in comparable behavior of the Marines. Once the FY whose rates to use is decided upon,

the first step is to calculate these rates for all the matrices discussed above, **Attrites** through **Two Grade Promotees To** and **Recruits**. As a second step, the **Beginning Strength** matrix of the current FY is then multiplied by these matrices, in order to provide the model with the gains and losses expected to occur in each category during the FY.

The **Attrites Rates** matrix is created by dividing the **Attrites** matrix by the **Beginning Strength** matrix of that FY, cell by cell. Then the **Beginning Strength** matrix of the current FY is multiplied by the **Attrites Rates** matrix to produce a matrix of attrites that are expected to occur during the current FY.

The **Demotees From** and the **Promotees From Rates** matrices are created in the same way; namely the **Beginning Strength** matrix of that FY divides both the **Demotees From** and the **Promotees From** matrices of the same FY. Then the **Beginning Strength** matrix of the current FY is multiplied by both matrices in order to produce the expected number of Marines who will be demoted from and promoted from respectively, during the current FY.

The **One Grade Demotees To Rates** matrix is produced slightly differently. The **One Grade Demotees To** matrix is divided by the **Beginning Strength** matrix of that FY, after the **Beginning Strength** matrix of that FY is first shifted one column to the left. This way, the number of one grade demotees in cell E-2, YOS 0 is divided by the E-3, YOS 0 cell from the **Beginning Strength** matrix of that FY. This must be done because all Marines demoted one grade to E-2, YOS 0 during the FY were originally in category E-3, YOS 0 at the beginning of the FY. Then the **Beginning Strength** matrix of the current FY, after a similar shift to the left, is multiplied by the **One**

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Grade Demotees To Rates matrix in order to produce a matrix of one grade demotees who are expected to occur during the current FY.

The **One Grade Promotees To Rates** matrix is calculated very similarly. The **One Grade Promotees To** matrix is divided by the **Beginning Strength** matrix of that FY, but instead of first shifting the **Beginning Strength** matrix of that FY one column to the left, it is shifted one column to the right. This produces the effect that the number of one grade promotees in cell E-2, YOS 0 is divided by the **Beginning Strength** in cell E-1, YOS 0 of that FY. The reason for this is that Marines being categorized within **the One Grade Promotees To** matrix were promoted by one pay grade during the FY, from one lower pay grade. Then the **Beginning Strength** matrix of the current FY, after a similar shift to the right, is multiplied by the **One Grade Promotees To Rates** matrix in order to produce a matrix of one grade promotees who are expected to occur during the current FY.

The **Two Grade Demotees To Rates** matrix is calculated the same way as the **One Grade Demotees To Rates** matrix explained above, except for one difference. Instead of shifting the **Beginning Strength** matrix of that FY one column to the left, it is now shifted two columns to the left. This way, the number of E-1, YOS 0, two grade demotees within the cell is divided by the E-3, YOS 0 cell from the **Beginning Strength** matrix of that FY. Again, the reason for the shift is that the Marines within the **Two Grade Demotees To** matrix came from the cell two pay grades to the right. Then the **Beginning Strength** matrix of the current FY, after a similar shift of two columns to the

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left, is multiplied by the **Two Grade Demotees To Rates** matrix in order to produce a matrix of two grade demotees who are expected to occur during the current FY.

The **Two Grade Promotees To Rates** matrix is calculated the same way as the **Two Grade Demotees To Rates** matrix, but instead of shifting left twice, the **Beginning Strength** matrix of that FY is shifted two columns to the right. This way, the number of E-3, YOS 0, two grade promotees within the cell is divided by the E-1, YOS 0 cell from the **Beginning Strength** matrix of that FY. The reason for the shift is that the Marines within the **Two Grade Promotees To** matrix came from the cell two pay grades to the left. Then the **Beginning Strength** matrix of the current FY, after a similar shift of two columns to the right, is multiplied by the **Two Grade Promotees To Rates** matrix in order to produce a matrix of two grade promotees who are expected to occur during the current FY.

The **Recruit Proportions** matrix is calculated differently. First a FY needs to be selected that most reflects the recruitment allocation that is expected to occur during the current FY. This may or may not be the same FY as the one selected for the rates matrices. Then the **Recruit** matrix in the chosen FY will be divided by the grand total of all recruits during that same FY. This will result in the **Recruit Proportions** matrix for that FY. Next, this matrix is multiplied by the total number of recruits expected by the model user to occur during the current FY. Note that this total should not include those recruits who are expected to attrite before the end of the current FY. To distinguish this number from historical data, it will be referred to as the number of accessions expected or needed to occur during the current FY and entered on the "Controls" sheet. By multiplying

this accession number into the **Recruit Proportion** matrix, the number of recruits expected to occur in each cell during the current FY is computed.

These matrices are then used to produce the total forecast. The forecast is calculated by simply subtracting losses and adding gains to each cell. Gains occur when Marines are promoted or demoted into the cell. Losses occur when Marines leave the cell, such as Marines who attrite, get promoted or demoted out of a cell.

This way, the forecast is calculated by adding gains and subtracting losses in each category, while advancing all personnel in each category by one YOS to account for the one year difference between the beginning and the end of the same FY. The following is a listing of how each matrix will affect the beginning strength matrix after the one YOS advancement:

> **Attrites** will be subtracted
> **Demotees From** will be subtracted
> **One Grade Demotees To** will be added
> **Two Grade Demotees To** will be added
> **Promotees From** will be subtracted
> **One Grade Promotees To** will be added
> **Two Grade Promotees To** will be added
> **Recruits** will be added (however not advanced one YOS)

The equation that expresses this computation is:

Forecasted **Beginning Strength** for FY+1= **Beginning Strength** for FY - **Attrites**

- **Demotees From** + **One Grade Demotees To**

+ **Two Grade Demotees To**

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- Promotees From + One Grade Promotees To

+ Two Grade Promotees To + Recruits (not advanced

one YOS)

Once this equation is applied to all the categories, a matrix of forecasted beginning

strengths for the next FY results.

Although forecasting beginning strength is not the primary goal of

this model, it is a good tool from which the user can analyze the number of accessions

based on different scenarios, as well as answer other questions concerning next FY's

strength. First of all, the model will calculate the number of accessions necessary in order

to maintain end strength. The model may accomplish this by doing exactly what is

described above with one exception: recruits are not added. Leaving the recruits out of the

computation produces a matrix of all the Marines who still remain in the Marine Corps

classified by YOS and pay grade. By simply taking the sum of all the cells within this

matrix and subtracting that sum from the total number of enlisted Marines authorized,

produces the total number of accessions needed to maintain end-strength. The equation for

this computation is the following:

Total Number of Accessions in FY+1 = Total Number of Enlisted Marines Authorized in FY+1

- Total Sum of Matrix Representing the Marines Who

Remain to the end of FY

(2) Using Straight Average Rates. The next level of forecasting

uses the straight average rates approach. This method is based on the same concept of

forecasting as the naïve approach, except it uses straight average rates matrices across four

relevant FY's instead of the rates matrices from a single FY as explained in the previous subsection.

The forecast using straight average rates is organized on two Excel worksheets named Straight Average Rates and Straight Average Forecast. The Straight Average Rates sheet is designed to determine the average rates of each category using mathematically correctly computed straight average rates. This is accomplished by first computing the **Straight Average Beginning Strength** matrix, which is calculated by referring back to the Raw Numbers sheet and simply adding together all **Beginning Strength** matrices, cell by cell, for all FY's and then dividing the sum by the number of FY's represented in the sum. For example, the cell representing E-1 with 0 YOS in the **Straight Average Beginning Strength** matrix is created by adding the E-1's with 0 YOS from each FY's **Beginning Strength** matrix on the Raw Numbers sheet and then dividing this total by the number of FY's (in this case four). This is programmed automatically by using the Excel function AVERAGE. This same computation is done for all cells within the **Straight Average Beginning Strength** matrix. The **Straight Average Attrites** matrix is calculated the same way. Simply adding all of the **Attrites** matrices from the Raw Numbers sheet, cell by cell, for all FY's and then dividing the sum by the number of FY's representing the sum. For example, the E-1 with 0 YOS cell within the **Straight Average Attrites** matrix is calculated by adding the E-1's with 0 YOS from each FY's **Attrite** matrix on the Raw Numbers sheet and then dividing this total by the number of FY's (in this case four). All the other straight average matrices, i.e., **Straight Average Demotees From** through **Straight Average Recruits**, are computed the same way.

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Next the model calculates the straight average <u>rates</u> matrices. This is accomplished by simply dividing each of the straight average matrices of attrition, demotion, and promotion by the **Straight Average Beginning Strength** matrix. For example, the matrix **Straight Average Rates of Attrites** is calculated by dividing **Straight Average Attrite** matrix by the **Straight Average Beginning Strength** matrix. Refer to the description of rate calculations in the previous subsection, because calculation of some of the rates matrices requires the beginning strength matrix to be first shifted one or two columns to the left or right, as appropriate.

The **Straight Average Recruit Proportions** matrix is calculated differently. First the total number of recruits is determined by finding the grand total of the **Straight Average Recruits** matrix, then divide each cell within that matrix by that grand total. The result is the **Straight Average Recruit Proportions** matrix.

The forecasting is then performed by multiplying the straight average rate matrices into the **Beginning Strength** matrix of the <u>current</u> FY, resulting in expected **Attrites** through **Two Grade Promotees To** during the current FY. **The Average Recruit Proportions** matrix is multiplied by "total number of expected accessions", which is determined by the user and entered on the "Controls" sheet, resulting in the expected number of recruits by pay grade and YOS. These matrices are then used to forecast the future beginning strengths with and without recruits and ultimately the number of recruits needed for the next FY, similarly to the approach described in subsection 1.

(3) Using Weighted Average Rates. Another forecasting technique used in this model is the weighted average. This forecast is calculated by the same basic

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process as the straight average forecast, but the computation of the rates is complicated by first weighting data of different FY's according to their considered relevance to the forecast to be obtained. These rates are computed on the sheet entitled Weighted Average Rates. The weighted average is constructed here using only the previous three FY's data. In this model, the three FY's used are FY95 through FY97. For this forecast, the users must determine the weights that they would like to place on each of the three previous FY's. The default weights are one for each of the FY's. These weights are then used to produce the weighted average for each category. For example, the **Weighted Average Beginning Strength** matrix is created by multiplying FY95 **Beginning Strength** matrix on the Raw Numbers sheet by the "three years prior weight," then repeating this process for FY96 with the "two years prior weight" and for FY97 with the "one year prior weight." Then the three products are added and the sum is divided by the sum of the weights. This process is then repeated for all of the matrices on this sheet, resulting in all the appropriate weighted average matrices.

The weighted average rates are calculated by simply dividing each weighted average matrix by the **Weighted Average Beginning Strength** matrix, again with the appropriate shifting to the left or right. The **Weighted Average Recruits** matrix is obtained by a similar weighted averaging process and then the weighted average proportion matrix is created by utilizing the same process as described during the straight average approach in the previous subsection. These rates and proportions are then used for forecasting, again in the same way as discussed in the previous subsections.

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2. Advantages

There are many advantages to using this model over the current Enlisted Inventory Projection Model. First of all, by considering pay grades as well as YOS separately, this model does not assume that all pay grades within a YOS will act similarly. In other words, this model can take into account the difference in promotion, demotion, attrition, and continuation rates of every pay grade and YOS. Therefore, provided the data are reasonably accurate, this model should increase the accuracy of the forecast.

Another advantage of this model is the flexibility that is built into it. This allows the user to create any number of different scenarios from which to conduct analysis. Namely, the user can use the weighted average method with any weighting of data from previous FY's, including the use of a single FY only. This can be accomplished by simply inputting a zero for the weight of any unwanted FY. This allows for the creation of both a two year weighted average forecast and a naïve forecast. Essentially the user is getting three different models in one.

This model is constructed to minimize the confusion caused by its complexity. It is carefully organized through the use of different sheets, strategically placed titles, and brief explanations within the model. With minimal effort, the user should be able to understand the design and calculations used within this model. This will allow the user to more efficiently use the model and, if necessary, make changes to the model.

3. Disadvantages

Although the disadvantages have been minimized as compared with the current model, some remain. In order to create the data for the Raw Numbers sheet, a large amount

of data manipulation must be accomplished within SAS. This requires an extensive knowledge of the data and of SAS in order to correctly extract the data required to run this model. This procedure can be very painstaking and time consuming, due to problems of inconsistency inherent in the data.

Another disadvantage of this model is its complexity as compared to the current model. The complexity requires some background and experience in forecasting to efficiently use this model. Still, this model can be used with a minimal forecasting knowledge. However, a greater degree of comprehension of forecasting is necessary to produce changes in the model that will be required from time to time, e.g., annually. Refer to the model's User's Manual in Appendix C for further explanation.

III. RESULTS

After painstaking analysis of available personnel data, this thesis has produced an enlisted inventory projection model to forecast future end strength by YOS and pay grade. In the process, the model makes use of attrition, promotion, and demotion rates computed from historical data. Some flexibility has also been incorporated into this model, furnishing the user with various options for analysis and scenario development. The primary goal of the model is to forecast the necessary accessions to meet required end strength.

The model is user-friendly as it includes a logical combination of explanations and labels. The model is organized to allow the user to easily run the model and conduct some sensitivity analysis on the results. More precise instructions for using the model are provided in the User's Manual in Appendix C.

The "Results" sheet of the model is organized into eight different sections, providing the user with the comprehensive results in an easily identifiable area.

The first two sections of the "Results" sheet are the "Straight Average Forecasted Number of Accessions" and the "Weighted Average Forecasted Number of Accessions". These two numbers are presented to the user with blue lettering and a gray background, labeled appropriately, to show the recommended total number of required accessions, i.e., the number of people that need to be recruited into the Marine Corps, in order to maintain the Congressionally mandated end strength figure. The numbers are calculated by the "Straight Average Forecasted Number of Accessions" and the "Weighted Average Forecasted Number of Accessions" described in Chapter II of this thesis. This display

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allows the analyst an instantaneous view of how the different forecasting methods compare with one another.

More details on these numbers are also contained on the "Results" sheet. The full matrices for "Straight Average Forecasted Number of Recruits" and the "Weighted Average Forecasted Number of Recruits" are displayed beneath the first two forecasts. These matrices present the user with the number of recruits expected during the current FY by YOS and pay grade. The number of E-1, YOS 0 accessions needed in order to maintain end strength for the current FY is an example of the information that can be obtained within these matrices.

Also displayed on the "Results" sheet are the "Straight Average Forecasted End Strengths" and the "Weighted Average Forecasted End Strengths" matrices. These matrices provide the user with the forecasted number of Marines by YOS and pay grade on 30 September of the current FY. For example, such questions as, "How many E-3, YOS 4 Marines are expected to be on active duty on 30 September of the current FY?" can be answered by these matrices.

The "Straight Average Forecasted End Strengths without Recruits" and the "Weighted Average Forecasted End Strengths without Recruits" are the last two matrices presented on this sheet. They furnish the user with the forecasted number of Marines by YOS and pay grade on 30 September of the current FY, without factoring in recruits during the current FY. These matrices forecast the number of Marines who will remain in the Corps to the end of the current FY and is instrumental in determining the number of accessions needed to meet the requirement as explained above.

A byproduct of this model are the rates matrices that can be found on the "Rates" sheet. These matrices provide the user with historical rates of **attrites, demotees from, one grade demotees to, two grade demotees to, promotees from, one grade promotees to, and two grade promotees to** for each available FY. The percentage of Marines in category E-1 with 1 YOS who attrited during FY94, or the percentage of Marines in category E-4 with 3 YOS who were double promoted during FY96 are examples of the information contained on this·sheet. The **Recruits Proportions** matrices are different, in that they provide percentages of recruits who are in the various categories by the end of the FY during which they were recruited. The percentage of recruits with a pay grade of E-1 and 0 YOS during FY95, e.g., is 23% of all Marines recruited during FY95 who stayed in the Corps to the end of that FY. A major advantage of this sheet is the fact that the information is presented in percentages. This improves the users ability to identify possible trends and/or problem areas. Also, since the information is presented in such minute detail, pinpointing any areas of concern should be fairly simple.

The "Raw Numbers" sheet furnishes the model user with additional information. Within this sheet the user can find the exact number of E-2's with 3 YOS that attrited during FY95 or the number of E-6's with 9 YOS that were demoted during FY97. This sheet provides the user with a large amount of historical information from which to answer specific questions, such as how many E-1's with 2 YOS were promoted one grade during FY95? Or with less detail, how many E-1's were promoted one grade during FY95? Or in the aggregate, how many Marines were promoted one grade during FY95?

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This model has been designed with the user in mind. The incorporated labels and short descriptions throughout the model allow the user to operate it without the use of references. The organization of the model also contributes to it being user-friendly. The functions that occur within the model were created on different worksheets. Each labeled worksheet promotes for better understanding of the model's construction and design. Each worksheet contains only a small portion of the model's construction, to allow for simple understanding and when the time arises, updating. Ultimately, the model's organization should increase its effectiveness to the user.

A characteristic of this model is the ability to produce desired results for analysis with minimal effort. The current model used by manpower planners provides the user with limited scenario testing. It requires the user to completely change the model in order to test different scenarios. On the other hand, the model developed for this thesis gives the user the opportunity to quickly compare different scenarios. The analyst can choose among using straight average, three year weighted average, two year weighted average and naïve forecasting techniques. Additionally, by simply altering the number of projected accessions and/or the total number of enlisted Marines, and/or the weights given to each FY, the user can analyze a large number of scenarios that depend on forecasting accession requirements to meet different end strength goals. This feature can dramatically save the user time when different scenarios are in need of analysis.

The model also provides the user with information that should be more accurate than the current model. The current model does not effectively consider how pay grade along with YOS affects attrition, demotion, and promotion rates. This model has been

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designed to calculate these rates for different pay grades and YOS. Thus, the user can more accurately analyze the behaviors of Marines, which should enhance the effectiveness of the user in analyzing manpower issues.

The inherent detail, flexibility, and user-friendly environment provided by this model should significantly enhance the capabilities of manpower analysts and allow for better decision-making.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This model provides the user with a number of enhancements over the current model used at HQMC for analyzing enlisted accession requirements. First, the model is based on more accurate mathematical principles. The rates used within the model were calculated correctly and therefore result in mathematically sound values. The model also furnishes its users with a more detailed analysis of the historical behavior of the enlisted force by incorporating the pay grade variable. As a consequence, the user can now determine attrition, demotion, and promotion rates by YOS as well as pay grade. Behaviors of an E-1 with 1 YOS can be analyzed with this model separately from that of an E-2 with 1 YOS. Another enhancement of this model is the ease with which a user can analyze different scenarios. By simply altering a few variables on the "Controls" sheet, the analyst can produce several different scenarios, which may be compared in their effects.

B. RECOMMENDATIONS

This model has been developed to overcome many of the currently used model's disadvantages. The detail and accuracy built into this model can provide the analyst with valuable information on which to base key accession and end strength decisions. Also with the built in flexibility, analysts should be able to easily and efficiently obtain results for many different scenarios. So, it is recommended that this model be considered for use with accession planning by the Enlisted Plans Section, HQMC.

C.   SUGGESTED FURTHER STUDIES

The effectiveness and flexibility of this model could be further enhanced by adding some other forecasting techniques to it. A brief list of some possible forecasting techniques follows:

1. Simple n-Year Moving Average Technique

This type of averaging for some or all of the attrition, promotion, and demotion rates will provide the user with new rates that automatically exclude data as they are becoming less relevant for the next forecast and replace them with data that have more recently become available.

2. Weighted n-Year Moving Average Technique

A further expansion on the n-Year Moving Average would be to use weights with each FY, thereby using Weighted n-Year Moving Average rates. Also, the Weighted n-Year Moving Average may be constructed to furnish the user with optimal weighting factors, which provide further insight into any analysis. [Ref 4: p. 625]

3. Exponential Smoothing Technique

This technique is also known as Exponentially Weighted Moving Average. It is very similar to the Weighted n-Year Moving Average, except this technique needs a smaller amount of historical data in order to obtain a forecast. [Ref. 5: p. 627] Although data storage is no longer as significant a problem as in past years, this technique can still prove to be of use when data are not available in sufficient quantity or if the user wants to use only a small portion of the historical data. Exponential Smoothing allows the user to obtain a

reliable forecast in both times of steady state and in times of dramatic change. Optimization can also be used with Exponential Smoothing. This technique is extremely flexible and can provide the user with many options. [Ref 4: p. 627]

4. Least Squares and Linear and Nonlinear Regression Techniques

The use of least squares can provide the user with functions based on average accessions over time. Regression analysis can be used to develop models where attrition is expressed as a function of various socioeconomic variables (e.g. unemployment rates or bonuses offered for reenlistment, etc) and analyzing their functional relationships. Once the latter is understood, such relationships may be built into the forecasting model. [Ref. 5: p. 609]

APPENDIX A. CURRENT MODEL'S CONTINUATION RATES

YOS	FY 86	FY 87	FY 88	FY 89	FY 90*	FY 91*	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
0	0.903	0.917	0.910	0.931	0.000	DIV/0!	0.910	0.908	0.917	0.929	0.910	0.897
1	0.919	0.907	0.906	0.905	0.000	DIV/0!	0.910	0.917	0.912	0.936	0.908	0.913
2	0.815	0.869	0.876	0.891	0.000	DIV/0!	0.892	0.882	0.886	0.913	0.897	0.898
3	0.461	0.431	0.394	0.411	0.000	DIV/0!	0.366	0.378	0.382	0.407	0.384	0.368
4	0.870	0.882	0.862	0.861	0.000	DIV/0!	0.753	0.698	0.709	0.728	0.761	0.774
5	0.902	0.909	0.891	0.885	0.000	DIV/0!	0.639	0.596	0.679	0.669	0.709	0.750
6	0.854	0.872	0.835	0.850	0.000	DIV/0!	0.811	0.807	0.834	0.900	0.863	0.895
7	0.860	0.832	0.786	0.803	0.000	DIV/0!	0.770	0.769	0.785	0.830	0.759	0.820
8	0.886	0.891	0.880	0.881	0.000	DIV/0!	0.856	0.870	0.894	0.912	0.863	0.891
9	0.899	0.899	0.884	0.884	0.000	DIV/0!	0.868	0.867	0.892	0.923	0.887	0.888
10	0.901	0.899	0.902	0.907	0.000	DIV/0!	0.887	0.871	0.913	0.920	0.901	0.892
11	0.898	0.906	0.877	0.900	0.000	DIV/0!	0.844	0.836	0.864	0.894	0.883	0.880
12	0.939	0.925	0.926	0.927	0.000	DIV/0!	0.863	0.837	0.837	0.855	0.839	0.846
13	0.962	0.957	0.960	0.950	0.000	DIV/0!	0.916	0.907	0.905	0.936	0.925	0.927
14	0.980	0.967	0.975	0.963	0.000	DIV/0!	0.950	0.899	0.943	0.961	0.952	0.954
15	0.987	0.975	0.979	0.975	0.000	DIV/0!	0.959	0.928	0.942	0.968	0.967	0.969
16	0.980	0.983	0.978	0.978	0.000	DIV/0!	0.954	0.933	0.946	0.980	0.964	0.971
17	0.996	0.987	0.990	0.987	0.000	DIV/0!	0.978	0.954	0.968	0.986	0.976	0.982
18	0.978	0.988	0.985	0.988	0.000	DIV/0!	0.986	0.981	0.982	0.747	0.995	0.992
19	0.650	0.646	0.657	0.571	0.000	DIV/0!	0.544	0.579	0.556	0.479	0.721	0.547
20	0.733	0.747	0.736	0.693	0.000	DIV/0!	0.633	0.699	0.659	0.526	0.782	0.640
21	0.775	0.760	0.800	0.742	0.000	DIV/0!	0.665	0.733	0.672	0.610	0.854	0.657
22	0.811	0.832	0.842	0.795	0.000	DIV/0!	0.750	0.800	0.734	0.707	0.892	0.781
23	0.880	0.877	0.879	0.833	0.000	DIV/0!	0.806	0.779	0.799	0.751	0.873	0.822
24	0.870	0.863	0.883	0.844	0.000	DIV/0!	0.844	0.833	0.802	0.705	0.905	0.812
25	0.807	0.825	0.765	0.801	0.000	DIV/0!	0.724	0.768	0.773	0.664	0.881	0.726
26	0.744	0.764	0.769	0.633	0.000	DIV/0!	0.707	0.685	0.698	0.693	0.878	0.735
27	0.832	0.768	0.848	0.747	0.000	DIV/0!	0.794	0.748	0.844	0.768	0.873	0.796
28	0.820	0.806	0.802	0.780	0.000	DIV/0!	0.701	0.857	0.771	0.360	0.854	0.877
29	0.297	0.200	0.260	0.194	0.000	DIV/0!	0.262	0.250	0.208	0.422	0.463	0.207
30	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000

* Data for these columns was determined by the manpower planners to be inappropriate for forecasting. Desert Shield and Desert Storm occurred during these FY's, thereby causing continuation rates to be overly inflated.

Continuation Rates by YOS using the Forecasting Techniques in the Current Model

YOS	str ave:	adj ave:	naive:	naive II:	weightl:	weightll:
0	0.913	0.911	0.910	0.897	0.908	0.903
1	0.913	0.910	0.908	0.913	0.916	0.911
2	0.882	0.889	0.897	0.898	0.901	0.898
3	0.398	0.394	0.384	0.368	0.381	0.374
4	0.790	0.737	0.761	0.774	0.761	0.769
5	0.763	0.674	0.709	0.750	0.721	0.733
6	0.852	0.863	0.863	0.895	0.886	0.882
7	0.801	0.795	0.759	0.820	0.804	0.796
8	0.882	0.885	0.863	0.891	0.887	0.880
9	0.889	0.892	0.887	0.888	0.895	0.888
10	0.899	0.902	0.901	0.892	0.900	0.896
11	0.878	0.877	0.883	0.880	0.884	0.881
12	0.880	0.846	0.839	0.846	0.846	0.843
13	0.934	0.919	0.925	0.927	0.928	0.926
14	0.955	0.946	0.952	0.954	0.955	0.953
15	0.965	0.967	0.967	0.969	0.968	0.968
16	0.967	0.969	0.964	0.971	0.971	0.968
17	0.981	0.976	0.976	0.982	0.981	0.980
18	0.962	0.986	0.995	0.992	0.944	0.993
19	0.595	0.594	0.721	0.547	0.585	0.616
20	0.685	0.692	0.782	0.640	0.660	0.697
21	0.727	0.715	0.854	0.657	0.707	0.736
22	0.794	0.776	0.892	0.781	0.799	0.825
23	0.830	0.816	0.873	0.822	0.823	0.842
24	0.836	0.837	0.905	0.812	0.818	0.849
25	0.773	0.774	0.881	0.726	0.760	0.788
26	0.731	0.725	0.878	0.735	0.770	0.792
27	0.802	0.802	0.873	0.796	0.813	0.827
28	0.763	0.808	0.854	0.877	0.767	0.868
29	0.276	0.262	0.463	0.207	0.327	0.310
30	1.000	1.000	1.000	1.000	1.000	1.000

APPENDIX B. "RAW NUMBERS" MATRICES

Beginning Strengths FY94

YOS/Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	10189	15568	3711	3	1	10	0	0	0
1	337	3432	20825	651	4	6	0	0	0
2	202	703	14391	5043	48	14	0	0	0
3	187	488	7494	12097	342	8	2	0	0
4	71	92	911	6032	1279	16	1	0	0
5	33	35	233	3232	2660	15	8	0	0
6	27	8	120	1402	3181	34	6	0	0
7	24	12	56	601	3520	123	5	1	0
8	16	5	18	139	3372	333	5	0	0
9	10	2	5	77	3616	726	23	0	0
10	6	2	9	48	2431	1184	27	1	0
11	11	3	5	21	1589	1791	62	0	0
12	6	3	3	14	816	2152	190	0	0
13	7	2	1	8	220	2033	354	6	0
14	7	1	1	0	65	1937	776	15	1
15	7	2	0	1	27	1368	1382	40	1
16	6	0	1	1	16	833	1698	133	0
17	0	2	3	1	5	506	1579	163	3
18	9	0	0	0	9	350	1498	416	10
19	3	0	0	0	5	287	1110	639	25
20	0	0	0	0	2	33	410	737	48
21	0	0	0	0	0	3	110	532	82
22	0	0	0	0	0	0	21	343	132
23	1	0	0	0	0	1	2	209	193
24	1	0	0	0	0	0	0	98	195
25	0	0	0	0	0	0	1	67	227
26	1	0	0	0	0	0	0	26	153
27	0	0	0	0	0	0	0	2	132
28	0	0	0	0	0	0	0	1	83
29	0	0	0	0	0	0	0	0	96
30+	0	0	0	0	0	0	0	2	15

Attrites FY94

YOS/Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	987	1986	533	17	15	1	1	0	0
1	84	276	833	31	12	1	0	0	0
2	54	140	775	198	9	0	0	0	0
3	65	190	2598	3460	75	1	1	0	0
4	16	42	279	853	142	7	3	1	0
5	5	9	77	636	398	10	0	1	0
6	2	6	29	180	256	5	1	1	0
7	5	4	23	154	321	12	1	0	0
8	9	1	9	32	156	15	2	0	0
9	3	2	2	21	221	23	3	2	0
10	0	1	6	10	126	34	2	1	0
11	3	0	4	2	182	57	3	2	0
12	3	3	2	3	191	71	7	2	0
13	6	3	0	3	57	51	4	1	0
14	0	3	1	0	14	57	5	0	0
15	2	2	5	1	5	86	5	0	0
16	1	1	1	2	4	48	14	1	0
17	0	0	0	1	3	23	12	0	0
18	2	0	0	0	1	12	6	0	0
19	2	0	0	0	2	112	263	72	2
20	1	0	0	1	1	19	107	88	1
21	0	0	1	1	0	2	38	82	3
22	1	1	0	1	0	0	13	49	6
23	1	0	0	0	0	1	2	25	14
24	0	0	0	0	0	0	0	21	15
25	0	0	0	0	0	0	0	9	24
26	0	0	1	0	1	0	0	7	19
27	0	0	0	0	0	0	0	0	11
28	0	0	0	0	0	0	0	1	10
29	0	0	0	0	0	0	0	0	36
30+	0	0	0	0	0	0	0	1	6

Demotees From FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	0	191	99	0	0	0	0	0	0
1	0	69	594	8	0	0	0	0	0
2	0	19	350	99	0	0	0	0	0
3	0	15	71	72	0	0	0	0	0
4	0	0	15	56	3	0	0	0	0
5	0	1	6	6	1	0	0	0	0
6	0	0	1	7	3	0	0	0	0
7	0	0	0	1	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	1	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0

43

1 Grade Demotee To FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	191	73	0	0	0	0	0	0	0
1	69	432	8	0	0	0	0	0	0
2	19	249	92	0	0	0	0	0	0
3	15	37	65	0	0	0	0	0	0
4	0	8	52	3	0	0	0	0	0
5	1	0	6	0	0	0	0	0	0
6	0	1	7	3	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	1	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0

2 Grade Demotees To FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	26	0	0	0	0	0	0	0	0
1	162	0	0	0	0	0	0	0	0
2	101	7	0	0	0	0	0	0	0
3	34	7	0	0	0	0	0	0	0
4	7	4	0	0	0	0	0	0	0
5	6	0	1	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	1	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0

Promotees From FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	8503	13366	687	3	0	0	0	0	0
1	125	2658	6123	43	0	0	0	0	0
2	35	317	7754	377	0	0	0	0	0
3	4	60	1523	733	0	0	0	0	0
4	1	16	229	1042	5	1	0	0	0
5	0	3	45	181	3	0	0	0	0
6	0	1	27	104	2	0	0	0	0
7	0	0	3	51	3	1	0	0	0
8	1	0	4	20	1	0	0	0	0
9	0	0	3	6	2	1	0	0	0
10	0	0	1	6	4	0	0	0	0
11	0	0	1	3	13	1	0	0	0
12	0	0	0	2	3	0	0	0	0
13	0	0	0	1	2	0	0	0	0
14	0	0	0	0	2	2	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	1	0	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	1	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0

1 Grade Promotee To FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	0	2889	13031	687	3	0	0	0	0
1	0	50	2486	6116	43	0	0	0	0
2	0	19	309	7746	377	0	0	0	0
3	0	3	57	1522	733	0	0	0	0
4	0	1	14	229	1042	5	1	0	0
5	0	0	2	44	181	3	0	0	0
6	0	0	1	27	104	2	0	0	0
7	0	0	0	3	51	3	1	0	0
8	0	0	0	4	20	1	0	0	0
9	0	0	0	2	6	2	1	0	0
10	0	0	0	1	6	4	0	0	0
11	0	0	0	1	3	13	1	0	0
12	0	0	0	0	2	3	0	0	0
13	0	0	0	0	1	2	0	0	0
14	0	0	0	0	0	2	2	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	1	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	1
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0

2 Grade Promotees To FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9
0	0	0	5614	335	0	0	0	0	0
1	0	0	75	172	7	0	0	0	0
2	0	0	16	8	8	0	0	0	0
3	0	0	1	3	1	0	0	0	0
4	0	0	0	2	0	0	0	0	0
5	0	0	0	1	1	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	1	0	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0

Recruits FY94

YOS/ Pay Grade	e-1	e-2	e-3	e-4	e-5	e-6	e-7	e-8	e-9	totals
0	11437	13529	2453	18	6	12	0	0	0	27455
1	26	427	350	4	1	0	0	0	0	808
2	0	3	3	1	0	0	0	0	0	7
3	0	1	1	2	0	0	0	0	0	4
4	0	0	2	19	3	1	0	0	0	25
5	0	1	2	15	4	0	0	0	0	22
6	0	0	3	1	9	1	0	0	0	14
7	0	0	0	1	3	0	0	0	0	4
8	0	0	0	0	3	0	0	0	0	3
9	0	0	0	0	1	0	0	0	0	1
10	0	0	0	1	2	1	0	0	0	4
11	0	0	0	0	1	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	1	0	0	0	0	1
14	0	0	0	0	0	1	1	0	0	2
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	1	0	0	0	1
17	0	0	0	0	0	1	1	0	0	2
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	1	0	0	1
21	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0
24	1	0	0	0	0	0	0	0	0	1
25	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
30+	0	0	0	0	0	0	0	0	0	0
Totals	11464	13961	2814	62	34	18	3	0	0	28356

APPENDIX C. USER'S MANUAL

A.   COMPATIBILITY AND REQUIREMENTS

This model requires a system capable of operating Microsoft Office 97. The model was constructed using Excel 97; however, it can be imported and operated by other spreadsheets if they contain a filter for Excel 97. [Ref. 7]

B.   OVERVIEW OF THE MODEL

This model is an enlisted inventory projection model that forecasts required accessions using years of service (YOS) and pay grade as variables. Four different techniques of forecasting: naïve, straight average, two year weighted average, and three year weighted average are feasible with the model. (Refer to Chapter II) The model actually forecasts end strength by pay grade and YOS and as such it can by used to analyze broader issues (involving end strength) in addition to forecasting accessions.

C.   LOADING THE MODEL

This model is an Excel based product. The user should first open the Excel program that meets the compatibility requirements listed in Section A. Within the Excel window, the user can open the model by selecting Open on the File menu button, then locating and selecting the file named "Accession Model.xls".

D. RUNNING THE MODEL

1. The Overview and Controls Sheets

Once the model opens, the first time user should ensure that the "Overview" sheet is active. This sheet provides the user with brief explanation of why the model was built and what it can do for the user. The model should automatically open to this sheet, but if it does not, simply click on the "Overview" tab at the bottom of the screen.

The next sheet the user should activate is the "Controls" sheet. Across the top of this sheet is the title of the model, "Marine Corps Inventory Projection Model for Accessions". Below the title is a button labeled "Stop Calculations". In normal mode, the model will automatically update its calculations as soon as data is entered. This button prevents the model from continuously updating whenever the user makes an input; thereby allowing the user to enter all inputs, then have the model calculate its results. Otherwise, the user may be subjected to constant delays while the model repeatedly runs through all calculations in response to each input.

Further down the sheet, the section titled "Inputs" is where the user should enter the data to be used in the model. The first request is to enter the "Specified End Strength", which can be the current total number of enlisted Marines or some other number the user would like to explore for feasibility. By entering different end strengths, the user can test different scenarios.

The next number to be entered is the "Number of Projected Accessions" or the total number of recruits the user would like to test for analysis. This lets the user analyze the impact of changes to the number of recruits/accessions.

Also under inputs is a subsection labeled "Weights". The data entered here are used by the model to calculate a forecast by using weighted averages as explained in Chapter II, Section B of this thesis. Since the three most recent FYs are used to produce the forecast, this allows the user to assign different weights to each of the three previous fiscal years depending on how the user thinks they should affect the forecast year. The weights can be used to obtain different types of forecasts including the naïve, two year weighted average, or three year weighted average forecasts. The naïve forecast can be obtained by simply selecting one of the three previous FYs then entering a one into the relevant FY's cell whose rates the user would like to use in the forecast, while entering a zero for the other two FYs. This will result in a model that only considers the rates of one FY when calculating the forecast. A two year weighted average forecast may be produced in a similar way by choosing two weights for two of the FYs and zero for the third FY. The three year weighted average is calculated by entering a factor for each of the three prior FYs.

The final object on the "Controls" sheet is a button labeled "Run Model". When this button is activated by the user all of the data entered on the sheet will be used to calculate the results which will be displayed on the "Results" sheet.

2. The Results Sheet

The "Results" sheet provides the user with all of the calculated forecasts contained within this model. These forecasts are presented so that the straight average and the

weighted average forecasts can be easily compared. The first cell on the sheet is a reminder to the user of the Number of Expected Accessions, which the user entered on the "Controls" sheet. The next two cells, with gray backgrounds, give the user the total number of accessions needed in order to maintain the total enlisted end strength. The first cell uses the straight average approach to determine this forecast, while the other cell uses weighted averages.

Continuing down the sheet, the next section is labeled "Detailed Results", which consists of six matrices calculated by using the Total Number of Enlisted Marines and the Number of Expected Accessions entered by the user. The two matrices labeled Straight Average Forecasted Number of Recruits and Weighted Average Forecasted Number of Recruits provide the user with a detailed forecast by pay grade and YOS of the number of recruits needed to maintain the desired enlisted end strength as computed by the straight average and the weighted average approaches, respectively.

The next two matrices entitled Straight Average Forecasted End Strengths and Weighted Average Forecasted End Strengths give the user the forecasted strengths by pay grade and YOS at the end of the current FY. They provide the user with a projection of how the enlisted force will be categorized on 30 September of the FY in question.

The final two matrices entitled Straight Average Forecasted End Strengths Without Recruits and Weighted Average Forecasted End Strengths Without Recruits furnish the user with end strengths by pay grade and YOS without recruits factored into the calculation of the forecast.

C. MAINTAINING THE MODEL

In order for this model to be used in future years, it must be updated at least annually. Updating this model, although not complicated, can be a time consuming task and requires a thorough understanding of the model's structure. To help with the updating process, the following sections are dedicated to explaining how to maintain the model in future years.

1. Extracting Data Using SAS

The first step to updating the model is to obtain the new FY's data from the Marine Historical and Statistical Files by merging the two files using SAS. The variables that need to be obtained from the data are as follows: **Beginning Strengths, Attrites, Promotees From, One Grade Promotees To, Two Grade Promotees to, Demotees From, One Grade Demotees To, Two Grade Demotees To**, and **Recruits**. Refer to Chapter II as how these variables are defined. This will create the new FY's data. Once this is completed the maintainer of the model can simply use the SAS code in Appendix D to extract the data in a form that can be used by this model.

The code will also have to be modified by increasing each year by one. For example this code:

```
IF ADBD GT '30SEP95'D THEN DELETE;
```

Should be changed to:

```
IF ADBD GT '30SEP96'D THEN DELETE;
```

Once the changes to the code are complete, the code, when activated, will produce a listing of Marines and tables by YOS and pay grade on which the model is based.

a. Updating the Raw Numbers Matrices

The matrices on the Raw Numbers sheet are compiled from tables created by the SAS code. Some of the tables produced by the code must by manipulated in order to obtain the matrices needed by the model. Once these matrices are created, they are entered onto the Raw Numbers sheet of the model. This sheet has been designed so that updating it can be done simply by entering the new matrices to the bottom of the sheet in the corresponding column. The following is an explanation of how to correctly produce the nine matrices needed as the basis for this model. Since the first updating will be done when complete FY98 data becomes available, the updating procedure will be explained in terms of FY98 matrices. Subsequent yearly updating can be affected analogously.

b. Beginning Strength Matrix

The first matrix to be created is the Beginning Strength matrix. The table that is produced by the "Beginning Strength Code" (see Appendix D) can be used without any manipulation. Simply convert the SAS table produced by the code into a matrix within Excel titled "Beginning Strength FY98". This can be accomplished by simply importing the table into Excel.

c. Attrites Matrix

The table that is produced by the "Attrition Code" can be used without any manipulation. Simply convert the SAS table produced by the code into a matrix within Excel titled "Attrites FY98".

d. One Grade Demotees To Matrix

The next matrix to construct is the **One Grade Demotees To** matrix. The table that is produced by the "Demotion Code" has to be somewhat manipulated to create this matrix. When entering this code into SAS, the maintainer of the model must ensure that the appropriate line of code is used as noted in Appendix D. In order to create the correct table, the line of code producing a table that only keeps records when the demotion results in a loss of one pay grade should be entered. With the resulting SAS table, the maintainer of the model can create a matrix within Excel entitled **"One Grade Demotees To FY98"**. Shifting this matrix to the left by one column, the appropriate matrix will result. This is accomplished by shifting the numbers in each column one cell to the left, thereby losing the numbers in the first column and ending up with all zeros in the last column of the shifted matrix. For example, all the numbers in the old column labeled "E-2" should be placed into the new column labeled "E-1" and all the old numbers in the column labeled "E-3" should be placed into the new column labeled "E-2". This should be done for all of the columns, which will ultimately leave the new column "E-9" with all zeros. This is logical, as it is impossible to get demoted into the E-9 pay grade. The shift is necessary because the SAS code produces tables where Marines are categorized by the pay grade <u>from</u>

which they were demoted. For this matrix, the Marines need to be categorized by the pay grade to which they were demoted. This way, the appropriate **"One Grade Demotees To FY98"** matrix will be produced.

e. Two Grade Demotees To Matrix

The table that is produced by the "Demotion Code" has to be somewhat manipulated to create this matrix. When entering this code into SAS, the maintainer of the model must ensure that the appropriate line of code is used as noted in Appendix D. In order to create the correct table, the line of code producing a table that only keeps records when the demotion results in a loss of two pay grades should be entered. With the resulting SAS table, the maintainer can create a matrix within Excel. This matrix then needs to be modified in order to produce the appropriate matrix titled **"Two Grade Demotees To FY98"**. Shifting this matrix to the left by two columns, the appropriate matrix will result. This is accomplished by shifting the numbers in each column two cells to the left, thereby losing the numbers in the first two columns and ending up with all zeros in the last two columns of the shifted matrix. For example, all the numbers in the old column labeled "E-3" should be placed into the new column labeled "E-1" and all the numbers in the old column labeled "E-4" should be placed into the new column labeled "E-2". This should be done for all of the columns, which will ultimately leave the new columns "E-8" and "E-9" with all zeros. This is logical, as it is impossible to get demoted by two pay grades and end up in either the E-8 or E-9 pay grades. The shift is necessary because when the SAS code produces the table, the Marines are categorized by the pay grade from which they were demoted. For this matrix, Marines need to be categorized by the pay grade to which they

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were demoted. This way, the appropriate **"Two Grade Demotees To FY98"** matrix has been produced.

f. Demotees From Matrix

This matrix is produced by using the two previous **Demotees To** matrices before the columns are shifted. Here, there is no shift required, because the tables produced by the SAS code already categorize the Marines using the pay grade from which they were demoted. So, take the matrices after they have been converted into Excel and (without shifting them) add the matrices to each other. This will result in the **"Demotees From FY98"** matrix.

g. One Grade Promotees To Matrix

The table that is produced by the "Promotion Code" has to be manipulated to create this matrix. When entering this code into SAS, the maintainer of the model must ensure that the appropriate line of code is used as noted in Appendix D. In order to create the correct table, the line of code producing a table that only keeps records when the promotion results in a gain of one pay grade should be entered. With the resulting SAS table, the maintainer can create a matrix within Excel. This matrix then needs to be modified in order to produce the appropriate matrix titled **"One Grade Promotees To FY98"**. Shifting this matrix to the right by one column, the appropriate matrix will result. This is accomplished by shifting the numbers in each column one cell to the right thereby losing the numbers in the last column and ending up with all zeros in the first column of the shifted matrix. For example, all the numbers in the old column labeled "E-1" should be

placed into the new column labeled "E-2" and all the numbers in the old column labeled "E-2" should be placed into the new column labeled "E-3". This should be done for all of the columns, which will ultimately leave the new column "E-1" with all zeros. This is logical, as it is impossible to get promoted into the E-1 pay grade. The shift is necessary because when the SAS code produces the table, the Marines are categorized by the pay grade from which they were promoted. For this matrix, the Marines need to be categorized by the pay grade to which they were promoted. This way, the appropriate **"One Grade Promotees To FY98"** matrix has been produced.

h. Two Grade Promotees To Matrix

The table that is produced by the "Promotion Code" has to be manipulated to create this matrix. When entering this code into SAS, the maintainer of the model must ensure that the appropriate line of code is used as noted in Appendix D. In order to create the correct table, the line of code producing a table that only keeps records when the promotion results in a gain of two pay grades should be entered. With the resulting SAS table, the maintainer can create a matrix within Excel. This matrix then needs to be modified in order to produce the appropriate matrix titled **"Two Grade Promotees To FY98"**. Shifting this matrix to the right by two columns, the appropriate matrix will result. This is accomplished by shifting the numbers in each column two cells to the right, thereby losing the numbers in the last two columns and ending up with all zeros in the first two columns of the shifted matrix. For example, all the numbers in the old column labeled "E-1" should be placed into the new column labeled "E-3" and all the numbers in the old column labeled "E-2" should be placed into the new column labeled "E-

4". This should be done for all of the columns, which will ultimately leave the new columns "E-1" and "E-2" with all zero's. This is logical, as it is impossible to get promoted into the E-1 and E-2 pay grades if the Marine is double promoted within a FY. The shift is necessary because when the SAS code produces the table, the Marines are categorized by the pay grade from which they were promoted. For this matrix, the Marines need to be categorized by the pay grade to which they were promoted. This way, the appropriate **"Two Grade Promotees To FY98"** matrix has been produced.

i. *Promotees From Matrix*

This matrix is produced by using the two previous **Promotees To** matrices before the columns are shifted. There is no shift required here, because the tables produced by the SAS code already categorize the Marines using the pay grade from which they were promoted. So, take the matrices after they have been converted into Excel and (without shifting them) simply add them to each other. This will result in the **"Promotees From FY98"** matrix.

J. *Recruits Matrix*

The table that is produced by the "Recruits Code" can be used without any manipulation. Simply convert the SAS table produced by the code into a matrix within Excel titled **"Recruits FY98"**.

2. Updating the Rates Sheet

Updating the rate matrices on the "Rates" sheet is a simple process. The sheet has been designed so that updating it can be accomplished by constructing the new FY rates matrices at the bottom of the sheet. Creating each matrix is described in Chapter III.

3. Updating the Straight Average Rates Sheet

The only matrices that need to be updated are the first row of matrices. These matrices produce the straight average numbers using all of the FY's of data available. When another FY of data becomes available, these data need to be incorporated into the straight average matrices. This is accomplished by ensuring the formula for each cell uses the new data when calculating the average. For example, the formula for the 94-98 Straight Average Number of Attrites in the cell E-1 with 0 YOS is:

=AVERAGE('Raw Numbers'!P4,'Raw Numbers'!P41,'Raw Numbers'!P78,'Raw Numbers'!P115, **'Raw Numbers'!Pxxx)**

with the x's being replaced with an appropriate row number of attrites in FY98 for the E-1 with 0 YOS. This will need to be accomplished for all of the other straight average number matrices on this sheet.

Lastly, the maintainer of the model should update the matrix titles by simply clicking on the cell with the title and changing it. The necessary changes will be made by the model automatically for the straight average rates matrices.

4. Updating the Straight Average Forecast Sheet

This sheet requires the maintainer of the model to do nothing more than update the titles of the matrices.

5. Updating the Weighted Average Rates Sheet

The first row of matrices within this sheet are the weighted average number matrices. These matrices display the weighted averages of the three previous FYs. Refer to Chapter II for more information. In keeping with the current concept of these matrices, they will have to be updated with the three most current FY's data. This can be accomplished by changing the formula of each cell. This formula will need to be changed in the following manner:

1. Remove the code that refers to the FY furthest in the past. In the current model that would mean removing the code that refers to FY95.

2. Then ensure that the three FY's being used are multiplied by the appropriate weight. For example when updating the model with FY98 data, FY96 should be multiplied by the "Weight 3 Years Prior", FY 97 should be multiplied by the "Weight 2 Years Prior", and finally FY98 should be multiplied by the "Weight 1 Year Prior". The resulting code should be as follows:

=($B$37*'Raw Numbers'!FY96+$B$38*'Raw Numbers'!FY97+$B$39*'Raw Numbers'!FY98)/$B$41

Wt 3 Yr Prior   Wt 2 Yr Prior   Wt 1 Yr Prior

3 Yr Prior Data   2 Yr Prior Data   1 Yr Prior Data

Once this has been completed, the titles of all the matrices need to be updated, resulting in an updated weighted average rates sheet.

Another option would be to expand to a four year weighted average. This can be accomplished by following the basic design principles provided in this section and in Chapter II, Section B.

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6. Updating the Weighted Average Forecast Sheet

This sheet requires the maintainer of the model to do nothing more than update the titles of the matrices.

APPENDIX D. SAS CODE

BEGINNING STRENGTH CODE

```
OPTIONS LINESIZE = 72   YEARCUTOFF = 1950;

***Converts date into a SAS date.***

DATA ONE;
      INFILE DD1 FIRSTOBS = 2 DELIMITER = ' ';
      LENGTH SSN $ 10;

      INPUT GRD $ SSN $ XADBD $ EAS  GRD1 $ SDN $ TTC $ TCC $ DOACT;

      ***Converts 6 character date into a SAS date***

            IF LENGTH(XADBD) = 6 THEN DO;
                  YYY = SUBSTR (XADBD, 1, 2)+0;
                  MMM = SUBSTR (XADBD, 3, 2)+0;
                  DDD = SUBSTR (XADBD, 5, 2)+0;
                  ADBD = MDY (MMM, DDD, YYY);
            END;

      ***Converts 8 character date into a SAS date***

            ELSE IF LENGTH(XADBD) = 8 THEN DO;
                  YYY = SUBSTR (XADBD, 1, 4)+0;
                  MMM = SUBSTR (XADBD, 5, 2)+0;
                  DDD = SUBSTR (XADBD, 7, 2)+0;
                  ADBD = MDY (MMM, DDD, YYY);
            END;
            ELSE ADBD = . ;
            DROP XADBD YYY MMM DDD;

***Limits data and allows for creation of transitional***
***data.                                             ***

      IF ADBD GT '30SEP95'D THEN DELETE;
```

```
***Sorts data by SSN***

PROC SORT DATA = ONE;
      BY SSN;

***Deletes all but one record, by comparing SSN's***

DATA THREE;
      SET ONE;
      IF SSN = LAG(SSN) THEN DELETE;

      ***Creating YOS variable, if fraction then rounds***
      ***down                                          ***

      YOS = FLOOR(('1OCT95'D - ADBD)/365.25);

***Creates table rows are YOS, columns are paygrade***

PROC FREQ DATA = THREE;
      TABLES YOS*GRD/NOPERCENT NOROW NOCOL;
```

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ATTRITION CODE

```
OPTIONS LINESIZE = 72   YEARCUTOFF = 1950;


***Converts date into a SAS date.***


DATA ONE;
      INFILE DD1 FIRSTOBS = 2 DELIMITER = ' ';
      LENGTH SSN $ 10;


      INPUT GRD $ SSN $ XADBD $ EAS  GRD1 $ SDN $ TTC $ TCC $ DOACT;


           ***Converts 6 character date into a SAS date***


           IF LENGTH(XADBD) = 6 THEN DO;
                 YYY = SUBSTR (XADBD, 1, 2)+0;
                 MMM = SUBSTR (XADBD, 3, 2)+0;
                 DDD = SUBSTR (XADBD, 5, 2)+0;
                 ADBD = MDY (MMM, DDD, YYY);
           END;


           ***Converts 8 character date into a SAS date***


           ELSE IF LENGTH(XADBD) = 8 THEN DO;
                 YYY = SUBSTR (XADBD, 1, 4)+0;
                 MMM = SUBSTR (XADBD, 5, 2)+0;
                 DDD = SUBSTR (XADBD, 7, 2)+0;
                 ADBD = MDY (MMM, DDD, YYY);
           END;
           ELSE ADBD = . ;
           DROP XADBD YYY MMM DDD;


      ***Limits data and allows for creation of transitional***
      ***data.                                            ***


      IF ADBD GT '30SEP95'D THEN DELETE;



***Keeps all records with attrition codes***
```

```
DATA THREE;
      SET ONE;
      IF TCC = 'R1' OR TCC = 'R3' OR TCC = 'R4';


***Merges records by SSN with attrition codes and any other***
***record with same SSN, keeps all records of anyone who   ***
***attrited                                                ***


DATA THREE;
      MERGE ONE(IN=INT) THREE(IN=INTH);
      BY SSN;
      IF INTH=1 THEN DELETE;


***Sorts data by SSN***


PROC SORT DATA=THREE;
      BY SSN;


***Deletes any duplicate records by looking for duplicate   ***
***SSN's                                                    ***


DATA FOUR;
      SET THREE;
      IF SSN=LAG(SSN) THEN DELETE;

      ***If the active duty base date is missing then delete ***
      ***record                                              ***

      IF ADBD=. THEN DELETE;

      ***Creating YOS variable, if fraction then rounds***
      ***down                                          ***

      YOS=FLOOR(('1OCT95'D-ADBD)/365.25);
      IF YOS<1 THEN YOS=0;


***Creates table rows are YOS, columns are paygrade***

PROC FREQ DATA=FOUR;
```

```
        TABLES YOS*GRD/NOPERCENT NOROW NOCOL;

***Prints the data that has been created by the above code***

PROC PRINT DATA=FOUR;
        VAR SSN ADBD GRD SDN TCC GRD1 DOACT;
```

```
                          ***DEMOTION CODE***


OPTIONS LINESIZE = 72    YEARCUTOFF = 1950;


***Converts date into a SAS date***


DATA ONE;
      INFILE DD1 FIRSTOBS = 2 DELIMITER = ' ';
      LENGTH SSN $ 10;


      INPUT GRD $ SSN $ XADBD $ EAS  GRD1 $ SDN $ TTC $ TCC $ DOACT;


            ***Converts 6 character date into a SAS date***


            IF LENGTH(XADBD) = 6 THEN DO;
                  YYY = SUBSTR (XADBD, 1, 2)+0;
                  MMM = SUBSTR (XADBD, 3, 2)+0;
                  DDD = SUBSTR (XADBD, 5, 2)+0;
                  ADBD = MDY (MMM, DDD, YYY);
            END;


            ***Converts 8 character date into a SAS date***


            ELSE IF LENGTH(XADBD) = 8 THEN DO;
                  YYY = SUBSTR (XADBD, 1, 4)+0;
                  MMM = SUBSTR (XADBD, 5, 2)+0;
                  DDD = SUBSTR (XADBD, 7, 2)+0;
                  ADBD = MDY (MMM, DDD, YYY);
            END;
            ELSE ADBD = . ;
            DROP XADBD YYY MMM DDD;


      ***Limits data and allows for creation of transitional***
      ***data.                                            ***


      IF ADBD GT '30SEP95'D THEN DELETE;



***Keeps records with demotion codes***


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```

```
DATA THREE;
      SET ONE;
      IF TCC='DC' OR TCC='D3';


***Merges records by SSN with demotion codes and any other***
***record with same SSN, keeps all records of anyone who  ***
***was demoted                                            ***


DATA THREE;
      MERGE ONE(IN=INT) THREE(IN=INTH);
      BY SSN;
      IF INTH=1;


***Takes all previous records and identifies only those   ***
***with an attrition code                                 ***


DATA FIVE;
      SET THREE;
      IF TCC='R1' OR TCC='R3' OR TCC='R4';


***Merges all records that include a demotion code with the***
***records that have attrition codes, then deletes any     ***
***record that has an attrition code and all other records ***
***with the same SSN                                       ***


DATA FIVE;
      MERGE THREE(IN=INT) FIVE(IN=INI);
      BY SSN;
      IF INI=1 THEN DELETE;


***Takes data and identifies only those records with      ***
***promotion codes                                        ***


DATA SEVEN;
      SET FIVE;
      IF TCC = 'DB' OR TCC= 'D2';


***Merges all current records with the records identified ***
***with promotion codes by SSN, then deletes any record   ***
***that has a promotion .code and all other records with  ***
```

```
***the same SSN                                              ***


DATA SEVEN;
      MERGE FIVE(IN=INT) SEVEN(IN=INS);
      BY SSN;
      IF INS=1 THEN DELETE;


***Sorts data by SSN and GRD1***


PROC SORT DATA=SEVEN;
      BY SSN GRD1;


***If both grd and grd1 have the same paygrade, then delete ***
***the record.  If grd is missing then delete the record   ***


DATA SEVEN;
      SET SEVEN;
            IF GRD=GRD1 THEN DELETE;
            IF GRD='' THEN DELETE;


***Deletes any duplicate records by looking for duplicate   ***
***SSN's                                                     ***


DATA TEN;
      SET SEVEN;
      IF SSN=LAG(SSN) THEN DELETE;


***Converts grd and grd1 characters into numbers***


DATA TEN;
      SET TEN;
      IF GRD='E1' THEN GRD=1;
      IF GRD='E2' THEN GRD=2;
      IF GRD='E3' THEN GRD=3;
      IF GRD='E4' THEN GRD=4;
      IF GRD='E5' THEN GRD=5;
      IF GRD='E6' THEN GRD=6;
      IF GRD='E7' THEN GRD=7;
      IF GRD='E8' THEN GRD=8;
      IF GRD='E9' THEN GRD=9;
```

```
IF GRD1='E1' THEN GRD1=1;
IF GRD1='E2' THEN GRD1=2;
IF GRD1='E3' THEN GRD1=3;
IF GRD1='E4' THEN GRD1=4;
IF GRD1='E5' THEN GRD1=5;
IF GRD1='E6' THEN GRD1=6;
IF GRD1='E7' THEN GRD1=7;
IF GRD1='E8' THEN GRD1=8;
IF GRD1='E9' THEN GRD1=9;
```

(The following four lines of code placed together for this explanation of the code only. The first, second and the last two lines were run in SAS without the other lines in order to obtain the correct data)

```
***Keeps only records when the demotion resulted in a  ***
***loss of 1 paygrade                                 ***

IF GRD-GRD1>1 THEN DELETE;

***Keeps only records when the demotion resulted in a  ***
***loss of 2 paygrades                                ***

IF GRD-GRD1>1;
IF GRD-GRD1<3;


***Creating YOS variable, if fraction then rounds***
***down                                           ***

YOS=FLOOR(('1OCT95'D-ADBD)/365.25);
IF YOS<1 THEN YOS=0;
```

```
***Creates table rows are YOS, columns are paygrade***

PROC FREQ DATA=TEN;
     TABLES YOS*GRD/NOPERCENT NOROW NOCOL;

***Prints the data that has been created by the above code***
```

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```
PROC PRINT DATA=TEN;
     VAR SSN ADBD GRD TCC GRD1 DOACT;
```

PROMOTION CODE

```
OPTIONS LINESIZE = 72   YEARCUTOFF = 1950;


***Converts date into a SAS date.***


DATA ONE;
      INFILE DD1 FIRSTOBS = 2 DELIMITER = ' ';
      LENGTH SSN $ 10;


      INPUT GRD $ SSN $ XADBD $ EAS  GRD1 $ SDN $ TTC $ TCC $ DOACT;


            ***Converts 6 character date into a SAS date***


            IF LENGTH(XADBD) = 6 THEN DO;
                  YYY = SUBSTR (XADBD, 1, 2)+0;
                  MMM = SUBSTR (XADBD, 3, 2)+0;
                  DDD = SUBSTR (XADBD, 5, 2)+0;
                  ADBD = MDY (MMM, DDD, YYY);
            END;


            ***Converts 8 character date into a SAS date***


            ELSE IF LENGTH(XADBD) = 8 THEN DO;
                  YYY = SUBSTR (XADBD, 1, 4)+0;
                  MMM = SUBSTR (XADBD, 5, 2)+0;
                  DDD = SUBSTR (XADBD, 7, 2)+0;
                  ADBD = MDY (MMM, DDD, YYY);
            END;
            ELSE ADBD = . ;
            DROP XADBD YYY MMM DDD;


      ***Limits data and allows for creation of transitional***
      ***data.                                            ***


      IF ADBD GT '30SEP95'D THEN DELETE;



***Keeps all records with promotion codes***
```

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```
DATA THREE;
      SET ONE;
      IF TCC='DB' OR TCC='D2';


***Merges records by SSN with promotion codes and any other***
***record with same SSN, keeps all records of anyone who   ***
***was promoted                                            ***


DATA THREE;
      MERGE ONE(IN=INT) THREE(IN=INTH);
      BY SSN;
      IF INTH=1;


***Keeps all records with attrition codes***


DATA FIVE;
      SET THREE;
      IF TCC='R1' OR TCC='R3' OR TCC='R4';


***Merges records by SSN with attrition codes and any other***
***record with same SSN, deletes all records of anyone who ***
***attrited                                                ***


DATA FIVE;
      MERGE THREE(IN=INT) FIVE(IN=INI);
      BY SSN;
      IF INI=1 THEN DELETE;


***Keeps all records with demotion codes***


DATA SEVEN;
      SET FIVE;
      IF TCC='DC' OR TCC='D3';




***Merges records by SSN with demotion codes and any other ***
***record with same SSN, deletes all records of anyone who ***
***was demoted                                             ***
```

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```
DATA SEVEN;
      MERGE FIVE(IN=INT) SEVEN(IN=INS);
      BY SSN;
      IF INS=1 THEN DELETE;


***Sorts data by SSN then by Date of Action in descending ***
***order                                                   ***


PROC SORT DATA=SEVEN;
      BY SSN DESCENDING DOACT;


***Deletes any duplicate records by looking for duplicate   ***
***SSN's                                                     ***


DATA TEN;
      SET SEVEN;
      IF SSN=LAG(SSN) THEN DELETE;


      ***Creating YOS variable, if fraction then rounds***
      ***down                                           ***


      YOS=FLOOR(('1OCT95'D-ADBD)/365.25);
      IF YOS<1 THEN YOS=0;
      IF GRD=GRD1 THEN DELETE;


***Converts grd and grd1 characters into numbers***


DATA TEN;
      SET TEN;
      IF GRD='E1' THEN GRD=1;
      IF GRD='E2' THEN GRD=2;
      IF GRD='E3' THEN GRD=3;
      IF GRD='E4' THEN GRD=4;
      IF GRD='E5' THEN GRD=5;
      IF GRD='E6' THEN GRD=6;
      IF GRD='E7' THEN GRD=7;
      IF GRD='E8' THEN GRD=8;
      IF GRD='E9' THEN GRD=9;
```

```
        IF GRD1='E1' THEN GRD1=1;
        IF GRD1='E2' THEN GRD1=2;
        IF GRD1='E3' THEN GRD1=3;
        IF GRD1='E4' THEN GRD1=4;
        IF GRD1='E5' THEN GRD1=5;
        IF GRD1='E6' THEN GRD1=6;
        IF GRD1='E7' THEN GRD1=7;
        IF GRD1='E8' THEN GRD1=8;
        IF GRD1='E9' THEN GRD1=9;
```

(The following three lines of code placed together for this explanation
of the code only. The first line Was run separately of the second and
third lines in SAS in order to obtain the correct data)

```
        ***Keeps only. records when the promotion resulted in an***
        ***increase of 1 paygrade                              ***

        IF GRD1-GRD>1 THEN DELETE;
        ***Keeps only records when the promotion resulted in an***
        ***increase of 2 paygrades                             ***

        IF GRD1-GRD>1;

        IF GRD1-GRD<3;
```

Creates table rows are YOS, columns are paygrade

```
PROC FREQ DATA=TEN;
        TABLES YOS*GRD/NOPERCENT NOROW NOCOL;
```

Prints the data that has been created by the above code

```
PROC PRINT DATA=TEN;
        VAR SSN ADBD GRD TCC GRD1 DOACT;
```

RECRUITS CODE

```
OPTIONS LINESIZE = 72   YEARCUTOFF = 1950;


***Converts date into a SAS date.***


DATA ONE;
      INFILE DD1 FIRSTOBS = 2 DELIMITER = ' ';
      LENGTH SSN $ 10;


      INPUT GRD $ SSN $ XADBD $ EAS  GRD1 $ SDN $ TTC $ TCC $ DOACT;


           ***Converts 6 character date into a SAS date***


           IF LENGTH(XADBD) = 6 THEN DO;
                 YYY = SUBSTR (XADBD, 1, 2)+0;
                 MMM = SUBSTR (XADBD, 3, 2)+0;
                 DDD = SUBSTR (XADBD, 5, 2)+0;
                 ADBD = MDY (MMM, DDD, YYY);
           END;


           ***Converts 8 character date into a SAS date***


           ELSE IF LENGTH(XADBD) = 8 THEN DO;
                 YYY = SUBSTR (XADBD, 1, 4)+0;
                 MMM = SUBSTR (XADBD, 5, 2)+0;
                 DDD = SUBSTR (XADBD, 7, 2)+0;
                 ADBD = MDY (MMM, DDD, YYY);
           END;
           ELSE ADBD = . ;
           DROP XADBD YYY MMM DDD;


      ***Limits data and allows for creation of central***
      ***data.                                         ***


      IF ADBD GT '30SEP96'D THEN ADBD=. ;


***Keeps all records with recruit codes***
```

```
DATA TWO;
      SET ONE;
      IF TCC='A0' OR TCC='A4';


***Merges records by SSN with recruit codes and any other  ***
***record with same SSN, keeps all records of anyone who   ***
***was recruited                                           ***


DATA TWO;
      MERGE ONE(IN=INO) TWO(IN=INT);
      BY SSN;
      IF INT=1;


***Keeps all records with attrition codes***


DATA FIVE;
      SET TWO;
      IF TCC='R1' OR TCC='R3' OR TCC='R4';


***Merges records by SSN with atttrition codes and any other***
***record with same SSN, deletes all records of anyone who  ***
***was attrited                                             ***


DATA FIVE;
      MERGE TWO(IN=INT) FIVE(IN=INI);
      BY SSN;
      IF INI=1 THEN DELETE;


***Sorts data by SSN then sorts date of action in descending ***
***order                                                     ***


PROC SORT DATA=FIVE;
      BY SSN DESCENDING DOACT;




***Deletes any duplicate records by looking for duplicate***
***SSN's                                                  ***

DATA FIVE;
```

80

```
      SET FIVE;
      IF SSN=LAG(SSN) THEN DELETE;

      ***Creating YOS variable, if fraction then rounds***
      ***down                                          ***

      YOS=FLOOR(('30SEP96'D-ADBD)/365.25);
      IF YOS<1 THEN YOS=0;

***Creates table rows are YOS, columns are paygrade***

PROC FREQ DATA=FIVE;
      TABLES YOS*GRD1/NOPERCENT NOROW NOCOL;

***Prints the data that has been created by the above code***

PROC PRINT DATA=FIVE;
      VAR SSN ADBD GRD TCC GRD1 DOACT;
```

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